Storage and Shelf Life of PACKAGED BLUEBERRIES

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U. S. DEPARTMENT OF AGRICULTURE Agricultural Marketing Service Market Quality Research Division

PREFACE

Duke Galletta of the Atlantic County (New Jersey) Blueberry Growers Association assisted in locating cooperators. John Bertino, Sr., and John Bertino, Jr., of Hammondton, N. J., made their packing shed and cold storage available for tests. Jack Rayner and W. F. Jeffers of Rayner Brothers Nursery, Salisbury, Md., made their packing shed available for the Maryland tests, and the Carolina Blueberry Cooperative Association made packing sheds available for the North Carolina tests. W. C. Ballinger, North Carolina State University horticulturist, cooperated in evaluating blueberries, containers, and films in North Carolina tests.

E. James Koch, Agricultural Research Service, assisted with the experimental design.

Pint containers were contributed by Container Corporation of America, Philadelphia, Pa., Keyes Fibre Company, New York, N. Y., Gilbert Plastics Incorporated, Hillside, N. J., and North Carolina Blueberry Growers' Cooperative, Burgaw, N. C.

Plastic films were contributed by American Viscose Company, Philadelphia, Pa., E. I. DuPont de Nemours Company, Wilmington, Delaware, and Celanese Corporation of America, Summit, New Jersey.

Trade names used in this report are for identification only of the materials tested, and do not constitute endorsement of these products by the Department of Agriculture or imply discrimination against other products.

This marketing research is part of a continuing program to reduce marketing losses and to extend the marketing season of agricultural products.

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SUMMARY

Because fresh blueberries are very perishable, great care is needed in marketing this delicate fruit. Highest quality is maintained by keeping blueberries at 32° F. and high humidity during storage and marketing. This was concluded by marketing specialists as a result of tests made during two seasons.

The tests also showed that plastic film lug liners increased the storage life of blueberries better than film covers for stacks of lugs.

Several consumer containers and films were tested. Each type is useful for modifying storage and marketing conditions.

By using a 32° F. storage temperature, suitable containers, and film caps for the individual boxes, and care in packing fairly decay-free fruit, high-quality blueberries can be marketed for 2 weeks after harvest. With some loss in quality, this marketing period can be extended to 4 weeks.

STORAGE AND SHELF LIFE OF PACKAGED BLUEBERRIES

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BACKGROUND

Blueberries were among the first fruits packaged in consumer units with transparent film caps. Blueberries have delicate skin and bloom, and are highly perishable. They need care and protection to maintain their quality during storage and marketing.

In Michigan, Bünemann and others (2)[1] reported that Rubel blueberries held up well for 4 to 6 weeks at 32° F. in a controlled atmosphere of 11-percent carbon dioxide and 10-percent oxygen. They held up well in normal atmosphere for 2 weeks at 32° or 40° but not at 50°. Alcoholic flavors developed in blueberries held in controlled atmospheres longer than 6 weeks at 32° or for 2 weeks at 50° or 72°. Bower and Dewey (1) and Woodruff and others (5) reported that Jersey and Rubel blueberries held up better for 18 days at 40° than for 6 days at 75°. In New Jersey, Stretch (4) reported that mold in blueberries was reduced as temperature was reduced. He noted the need for refrigeration and made recommendations for handling fresh blueberries. In Germany, de Haas and others (3) found -2° to +4° C. (28.4 to 39.2° F.) favorable for fresh blueberry storage and that storage life decreased at higher storage temperatures.

The present tests were conducted with blueberries grown near Burgaw, N. C., Salisbury, Md., and Hammondton, N. J. They were conducted at the growing areas and in laboratories at Raleigh, N. C., and Beltsville, Md. The purpose was to determine the storage and shelf life of commercially and experimentally handled and packaged blueberries and to devise ways of extending the storage and shelf life.

PROCEDURE AND RESULTS

Commercially Packaged Consumer Units of Blueberries

Nine hundred pints of commercially packaged blueberries, ready for retail sale, were used in these tests. The fruit was held at 32°, 40°, or 50° F., with a relative humidity at each temperature of approximately 85 percent. The 900 pints came from 10 lots of blueberries: Jersey variety from North Carolina in 1959, and from both Maryland and New Jersey in 1958 and 1959; Stanley variety from Maryland in 1958 and 1959; Coville variety from New Jersey in 1958; Rancocas variety from North Carolina in 1959; and Bluecrop from New Jersey in 1959. Each sample for evaluation consisted of three pints from each lot for each temperature, length of storage, and time of examination. The experiment was set up and analyzed as a split split-plot test with storage temperatures as whole plots and lots as replicates. Storage time was the first split, and time of examination (at removal from storage or after 2 days at 70° F. and 50 percent relative humidity) was the second split. The purpose of this experiment was to determine the effect of storage temperature and length of storage on the keeping quality of blueberries.

[1] Underscored figures in parenthesis refer to Literature Cited, page 16.

The blueberries were packaged in commercial sheds in growing areas. Wood-veneer pint containers were used. Each filled container was capped with a sheet of 300 PHT[2] cellophane secured over the container mouth with a rubber band. Twelve containers were packed into each wood-slatted, New Jersey-type shipping lug (figure 1). Although some corrugated paper shipping lugs are used commercially in North Carolina, and some combined fiberboard and wood lugs are used in Maryland, only wood-slatted New Jersey type shipping lugs were used in these tests to eliminate possible variation caused by different shipping containers. One sample (3 pints) of blueberries from each lot was examined before storage; others after holding at 32°, 40°, or 50° F. each at 85 percent relative humidity for 1, 2, 3, or 4 weeks. Additional samples were examined after 2 days at 70° F. and 50 percent relative humidity following removal from storage to simulate nonrefrigerated conditions during marketing.

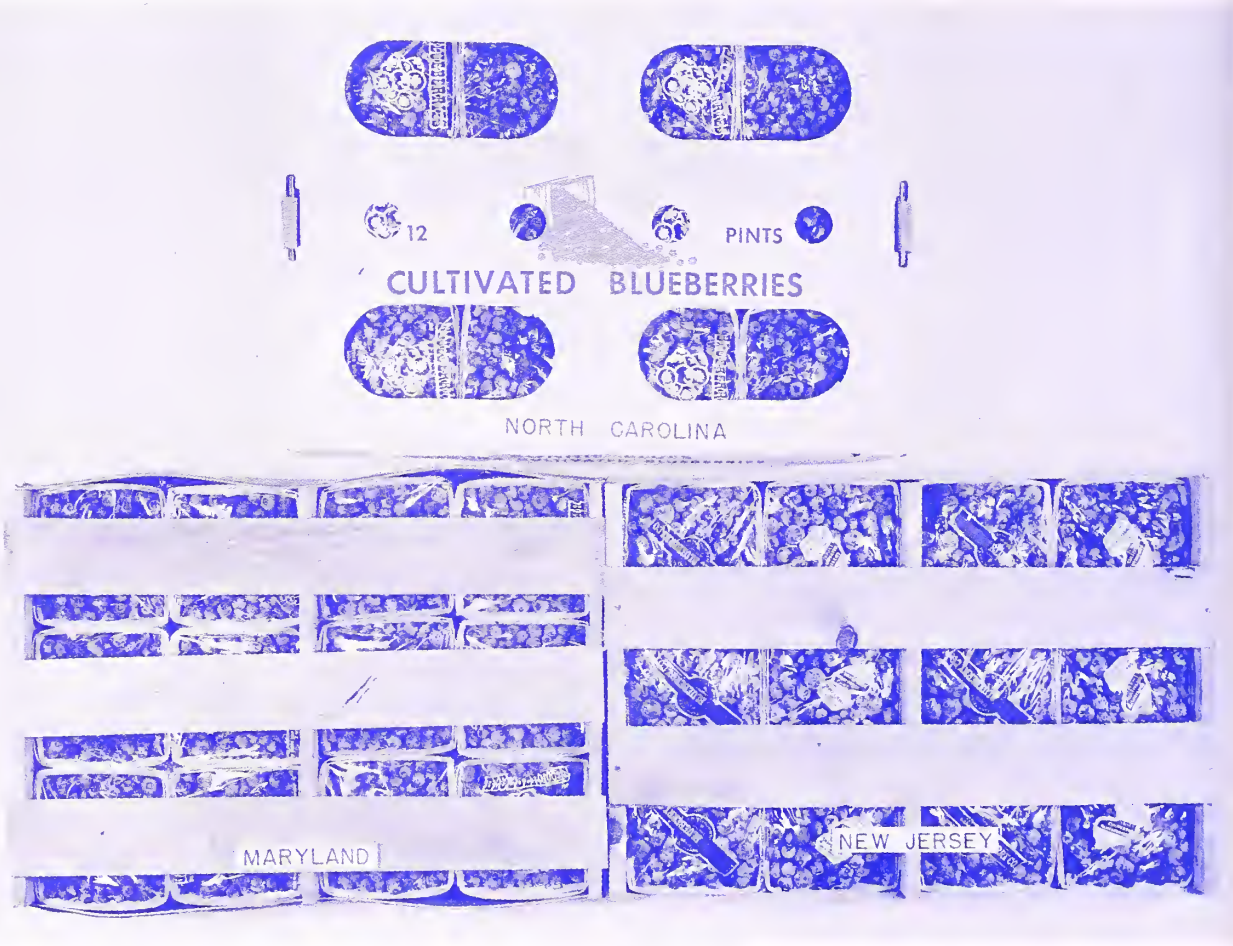

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FIGURE 1--Blueberries in film-capped pints within North Carolina, Maryland, and New Jersey shipping containers. New Jersey shipping containers were used in holding tests.

Weight loss, decay, and commercial waste were determined. Decay was based on 100 randomly selected fruit from each pint. The 100 berries were cut so that internal as well as external rot or breakdown could be observed (figure 2). Commercial waste was based on an examination of each pint, much as a housewife might do in removing spoiled fruit, green fruit, shrivelled fruit, and chaff from the desirable fruit in preparation for pie making or fresh dessert.

[2] P = plain (nonmoistureproof); H = partially resistant to blocking in humid atmosphere; T = transparent (uncolored).

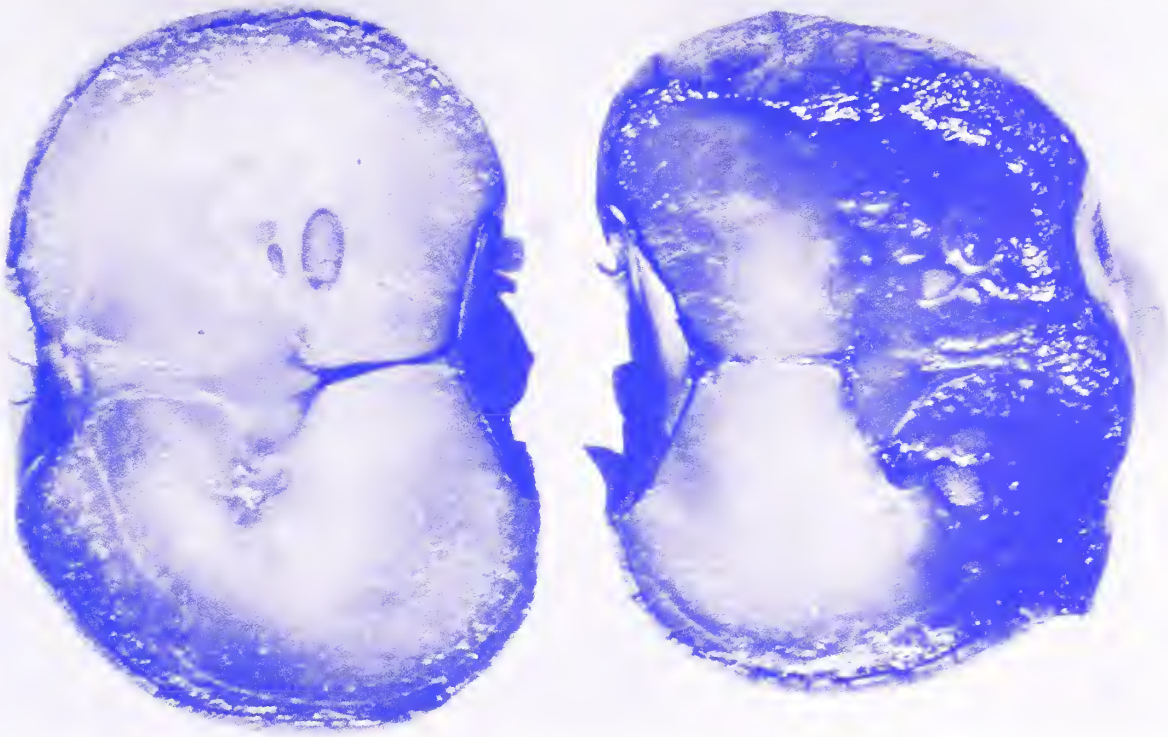

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FIGURE 2--Cross-section of sound blueberry (left) and decayed blueberry (right).

Weight Loss.--Weight loss in commercially packaged blueberries held at 85-percent relative humidity averaged about 1 percent per week at 32° F.; 1½ percent per week at 40°, and about 2 percent per week at 50° (table 1). During storage, weight loss was the highest the first week. After storage, it averaged 3.5 to 4 percent during 2 days at 70°. In packaged blueberries with 5 percent or more weight loss, shriveling was serious and detracted from appearance (figure 3). Because decay and mold growth masked undeterminable amounts of shriveling, no shriveling data are included in table 1.

Decay.--Decay averaged 1.4 percent when fruit was examined at time of packaging in the growing areas (table 2). Decay increased most in fruit stored at 50° F., and least in fruit stored at 32°. Decay also increased rapidly during 2 days' holding at 70°, following storage at 32°, 40°, or 50°. After 4 weeks' storage plus 2 days at 70°, decay averaged 28.2 percent in the fruit stored at 32°, 47.7 percent in that stored at 40°, and 71.2 percent at 50°.

Commercial Waste.--Commercial waste (decayed fruit, green fruit, shriveled fruit, and chaff) averaged 5.9 percent in blueberries packaged in the growing areas (table 3). At removal from storage after 4 weeks, waste averaged 18 percent in fruit held at 32° F., 30.1 percent at 40°, and 69.6 percent at 50°. After 4 weeks' storage, plus 2 days at 70°, commercial waste averaged 35.7 percent in fruit stored at 32°, 55.2 percent in fruit stored at 40°, and 82.2 percent in fruit held at 50°.

Shelf Life.--Considering 5-percent commercial waste as the maximum for good commercial practice and 10 percent as maximum for fair to poor practice, the blueberries in these tests averaged more waste (5.9 percent) when packaged than good practice permits. However, using the increase in waste after harvest (instead of total waste) as the criterion, shelf life may be estimated. Packaged blueberries held up well (up to

TABLE 1.--Weight loss in commercially packaged consumer units[1] of blueberries stored at 32°, 40°, or 50° F. and 85 percent relative humidity and after 2 days at 70° and 50 percent relative humidity following removal from storage [2]

Storage temperature	Start		Weight loss after indicated storage period							
			1 week		2 weeks		3 weeks		4 weeks	
		2 days at 70° F.	At removal	Plus 2 days at 70° F.	At removal	Plus 2 days at 70° F.	At removal	Plus 2 days at 70° F.	At removal	Plus 2 days at 70° F.
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
32° F.	0 a	4.2 fg	1.8 b	4.9 hi	2.6 c	6.4 klm	3.0 cd	6.7 lmn	4.0 ef	6.8 mn
40° F.	0 a	4.2 fg	2.2 bc	5.4 ij	3.5 de	7.3 n	4.7 gh	8.5 op	6.0 jk	9.0 p
50° F.	0 a	4.2 fg	3.0 cd	6.1 kl	4.4 fgh	8.9 p	6.3 klm	11.0 q	8.2 o	11.8 r

[1] Capped with 300 PHT cellophane.

[2] Letters after percent values indicate Duncan Multiple-Range Test significance values at the 5% level. Figures with no letters in common are significantly different. Figures with the same letter are not significantly different. Each value is an average of 30 pints.

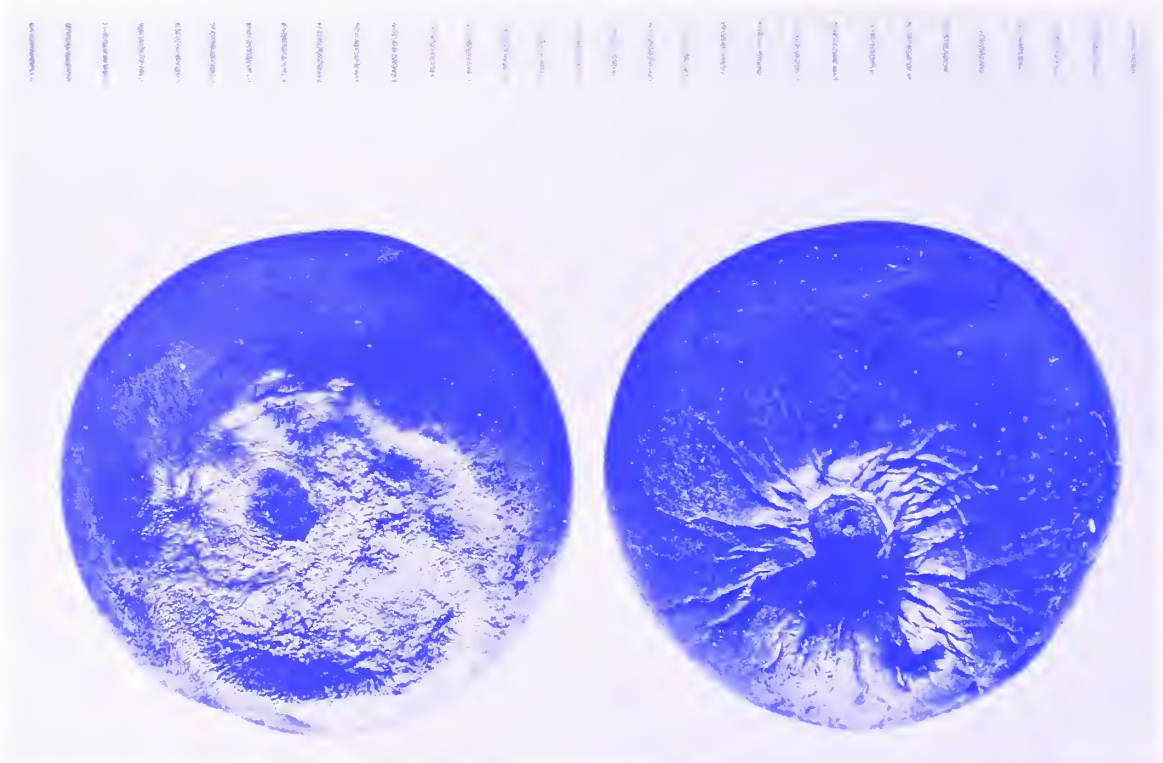

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FIGURE 3--Shriveled blueberries. Shriveling becomes serious when moisture loss reaches 5 percent.

TABLE 2.--Decay in blueberries stored at 32°, 40°, or 50° F. and 85 percent relative humidity, and after 2 days at 70° and 50-percent relative humidity following removal from storage[1]

Storage temperature	Start		Decay after indicated storage period							
			1 week		2 weeks		3 weeks		4 weeks	
		2 days at 70°	At removal	Plus 2 days at 70°	At removal	Plus 2 days at 70°	At removal	Plus 2 days at 70°	At removal	Plus 2 days at 70°
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
32° F.	1.4 a	8.3 a-d	4.8 ab	13.7 b-f	9.0 a-d	21.4 f-h	10.9 a-e	24.6 g-i	16.4 d-g	28.2 hi
40° F.	1.4 a	8.3 a-d	6.1 a-c	19.8 e-h	15.6 c-g	31.1 ij	26.7 hi	39.4 jk	27.7 hi	47.7 kl
50° F.	1.4 a	8.3 a-d	13.0 b-f	26.4 hi	31.4 ij	40.7 k	41.9 k	55.1 lm	60.1 m	71.2 n

[1] Letters after percent values indicate Duncan Multiple Range Test significance values at the 5% level. Figures with no letters in common are significantly different. Figures with same letter are not significantly different. Dash indicates that all intervening letters are included. Each value is an average of 30 pints.

TABLE 3.--Commercial waste[1] in cellophane-capped pint consumer units of blueberries stored at 32°, 40°, or 50° F. and 85-percent relative humidity, and after 2 days at 70° and 50 percent relative humidity following removal from storage[2]

Storage temperature	Start		Waste after indicated storage period							
			1 week		2 weeks		3 weeks		4 weeks	
		2 days at 70°	At removal	Plus 2 days at 70°	At removal	Plus 2 days at 70°	At removal	Plus 2 days at 70°	At removal	Plus 2 days at 70°
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
32° F.	5.9 a	10.8 abc	8.6 ab	14.4 bcd	10.1 abc	18.0 cde	15.6 bcde	28.2 fg	18.0 cde	35.7 gh
40° F.	5.9 a	10.8 abc	9.6 abc	17.9 cde	12.5 abc	28.2 fg	23.1 def	43.2 hi	30.1 fg	55.2 j
50° F.	5.9 a	10.8 abc	14.0 bc	24.1 ef	31.0 fg	43.6 hi	48.6 ij	63.3 k	69.6 k	82.2 l

[1] Commercial waste includes spoiled fruit, green fruit, shrivelled fruit, and chaff.
[2] Letters after percent values indicate Duncan Multiple Range Test significance values at the 5% level. Figures followed by the same letter are not significantly different. Figures followed by no letters in common are significantly different. Each value is an average of 30 pints.

5 percent waste increase) at 32° F. for 2 weeks, at 40° for 1 week, and at 70° for 2 days. They held up fairly well (up to 10 percent waste increase) for 3 weeks at 32° or for 1 week at 32° plus 2 days at 70°, at 40° for 2 weeks, and at 50° for 1 week.

Considerable variation in decay and waste was found from lot to lot. One State, at least, has set up minimum standards of quality for marketing fresh blueberries. Inasmuch as blueberries are grown in several states and marketed in many others, it would seem desirable to have uniform federal grades and standards to help buyers and sellers. No federal grades for fresh blueberries are in use now nor have they been established.[3]

Blueberries Stored in Polyethylene Lug Liners or Under Polyethylene Stack Covers

Field-run Burlington blueberries were used in commercial storage tests during 1958 and 1959 at Hammondton, N. J. Blueberries were harvested into and stored in lugs containing 12 wood-veneer pint cups (figure 4). Storage temperature was 32° F., with relative

[3] Work has been going on for some time on the development of U. S. grade standards for blueberries.

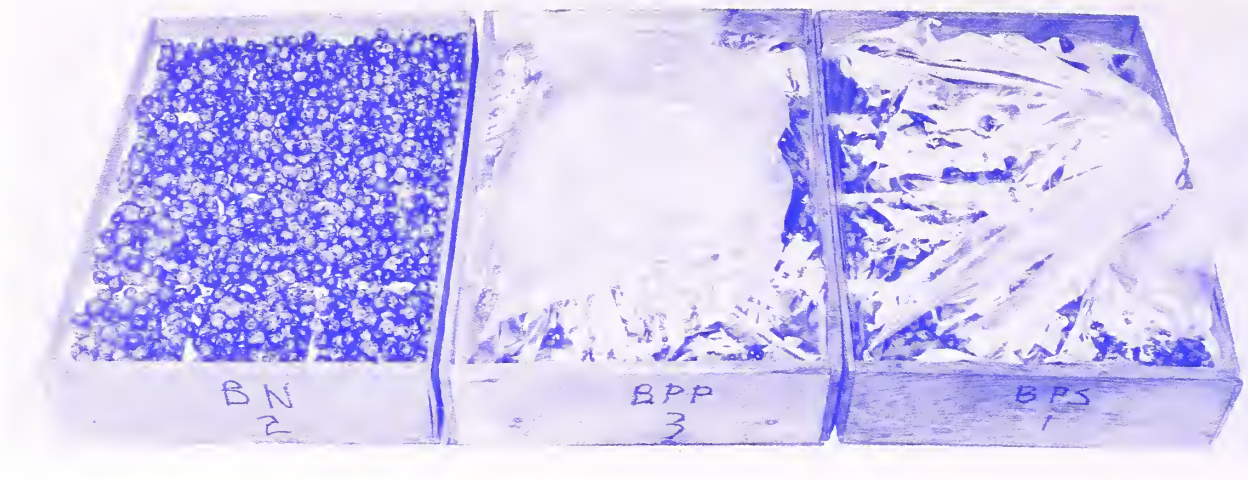

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FIGURE 4--Field and storage lugs of Burlington blueberries after 2 weeks at 32° F. and 85 percent relative humidity. The storage life of nonwrapped and wrapped fruit (in sealed and perforated polyethylene lug liners) were compared.

humidity about 85 percent. In each filled lug, the berries in pints were either: Naked (nonwrapped); enclosed in a perforated (twenty 1/8-inch holes); or in a tightly sealed 1.5-mil polyethylene liner bag measuring 32 inches by 18 inches, with $6\frac{1}{2}$-inch gussets (figure 4). In 1959, three stacks of filled lugs (22 lugs high) were each enclosed in 1.5-mil polyethylene stack covers. During the 1958 season, fruit placed in storage July 22 was removed after 2, 6, and 7 weeks. Fruit stored August 5 was removed after 5 weeks. During 1959 fruit stored August 20 was removed after 2, 4, and 5 weeks. At each examination, package atmosphere (carbon dioxide and oxygen), and fruit flavor determinations were made. A total of 156 pints was examined for decay and shriveling. Results are summarized in table 4. Limited tests (not included in table 4) showed the same effect whether polyethylene bags were used as lug over-wraps or as lug liners.

Weight Loss.--Weight loss averaged slightly less than 1 percent per week in the naked fruit and about 0.3 percent per week in fruit in lugs lined with perforated or sealed polyethylene bags. The stack covers allowed somewhat more weight loss from berries than individual lug liners because moisture could still be lost to the wooden lugs under stack covers.

Shriveling of the blueberries accompanied moisture loss. Polyethylene-enclosed fruit had only one-half to one-tenth as much shriveling as unwrapped fruit. Generally, shriveling became serious when weight loss was about 5 percent, but in 1959 the Burlington blueberries had appreciable shriveling with much lower weight losses. This was possibly due to storing physiologically older fruit.

Decay.--Polyethylene lug liners or stack covers had no consistent effect on decay. This was true whether the liners were sealed or perforated. An appreciable amount of decay was present in these field-run blueberries when they were placed in storage, and it increased during storage. Shippers did some sorting following harvest or storage, but left considerable decayed fruit in their commercial pack.

Flavor.--In limited observations, fruit in tightly sealed polyethylene lug liners had better flavor than that in perforated polyethylene or with no liner during 6 weeks' storage at 32° F. But after 7 weeks at 32°, off-flavors developed in the blueberries within some of the sealed polyethylene liners. After 7 weeks' storage, carbon-dioxide content ranged from 3 to 5 percent within the sealed liners, while oxygen ranged from 1.5 to 18 percent. When oxygen was found to be 4.5 percent in one lug and 1.5 percent in another lug, the fruit had an off odor. In the film-lined lug with 1.5 percent oxygen the berries were also off-flavored.

TABLE 4.--Weight loss, decay, and shriveling in Burlington blueberries in field lugs, as influenced by polyethylene lug liners or stack covers in 32° F. storage with 85 percent relative humidity[1]

Storage period and type of polyethylene protection[2]	1958 season[3]		1959 season	
	Weight loss	Decayed and shriveled berries	Weight loss	Decayed and shriveled berries
	Percent	Percent	Percent	Percent
None (initial)	0	14.4	0	9.2
2 weeks:				
None (control)	2.5	23.6	2.2	25.7
Perforated lug liner	.8	20.0	1.4	22.8
Sealed lug liner	.8	19.4	1.4	19.0
Stack cover	---	---	2.0	28.7
4 weeks:				
None (control)	---	---	3.0	37.7
Perforated lug liner	---	---	1.9	30.0
Sealed lug liner	---	---	1.6	20.6
Stack cover	---	---	3.6	40.5
5 weeks:				
None (control)	3.8	21.6	4.4	42.8
Perforated lug liner	0	18.8	1.3	33.8
Sealed lug liner	0	17.2	1.3	31.9
Stack cover	---	---	2.6	45.2
6 weeks:				
None (control)	4.7	40.6	---	---
Perforated lug liner	1.7	26.0	---	---
Sealed lug liner	.8	23.3	---	---
Stack cover	---	---	---	---
7 weeks:				
None (control)	5.0	45.3	---	---
Perforated lug liner	1.2	43.0	---	---
Sealed lug liner	.4	43.8	---	---
Stack cover	---	---	---	---

[1] Decay and shriveling percentages are based on 6 pints each. Weight loss percentages are based on 6 lugs each.

[2] Liners and stack covers made of 1.5-mil polyethylene. Perforated liners had 20 1/8-inch holes.

[3] Fruit stored 5 weeks placed in storage August 5, 1958. All other fruit this season placed in storage July 22.

Pint-Sized Containers for Marketing Blueberries

Four types of pint-sized containers for marketing blueberries were tested in North Carolina in 1958.

Twelve containers of each of the four types (figure 5)--wood-veneer, molded-pulp, plastic-mesh, and waxed-chipboard--were filled with Croatan blueberries. Six containers of each type were capped with a square of 1-mil Mylar (polyester film) secured by a rubber band around the container. The other six of each type were left naked (noncapped). Three capped and three naked pints of blueberries of each of the four container types were weighed and placed at 50° F. and a like number at 32° with a relative humidity of 85 percent in each storage room.

After 1 week at 50° F. or 2 weeks at 32°, the filled containers were reweighed and moved to 70° and 50 percent relative humidity for holding 2 additional days before a second reweighing and final examination. The percentage of decay and weight loss were determined. In general, weight loss was highest when fruit was stored in plastic or molded-pulp containers, intermediate in wood-veneer containers, and lowest in waxed chipboard containers (table 5). Weight loss in Mylar-capped containers was usually less than one-half as great as in non-capped containers.

Decay was high in these tests and was not consistently related to type of container or capping with film. Decay was higher in blueberries held 1 week at 50° F. plus 2 days at 70° than in blueberries held 2 weeks at 32° plus 2 days at 70°.

Where decay is not a problem and weight loss is apt to be severe, waxed-chipboard containers with film caps should give greater protection.

Capping Films for Pint-Sized Containers of Blueberries

Fifty-four wood-veneer pint containers of Croatan blueberries were used to test eight capping films in North Carolina in 1958. Each of six pints was capped with a square of one of eight commercial transparent films and six pints were left naked as controls. After weighing, three pints from each group of six were stored at 50° F. and 85 percent relative humidity for 1 week. The other three pints were placed at 32° and 85 percent relative humidity for 2 weeks' storage. After storage the packaged blueberries were reweighed and placed at 70° and 50 percent relative humidity for holding 2 additional days before a second reweighing and final examination. Moisture condensation on films was rated during storage at 32° or 50°, on placing at 70°, and after 2 days at 70°. The percentage of decay and weight loss were determined.

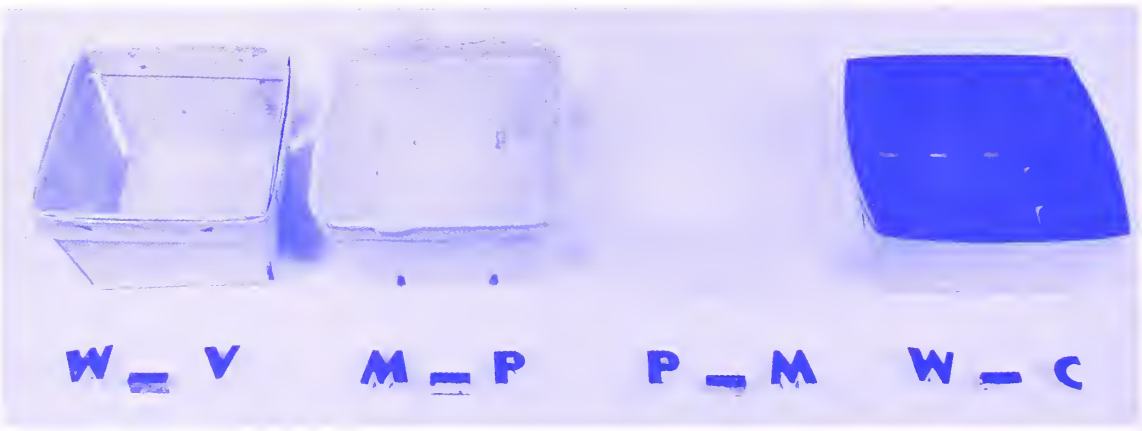

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FIGURE 5--Pint containers for retailing blueberries:
W-V = wood veneer; M-P = molded pulp;
P-M = plastic mesh; W-C = waxed chipboard.

TABLE 5.--Weight loss and decay in Croatan variety blueberries in naked (nonwrapped) or film-capped pint containers of wood-veneer, molded-pulp, plastic-mesh, or waxed-chipboard stored 1 week at 50° F. and 85 percent relative humidity or 2 weeks at 32° F. and 85 percent relative humidity and held 2 additional days at 70° F. and 50-percent relative humidity following storage.

Storage period	Container type	Weight loss				Decay[2]	
		During storage		Plus 2 days at 70° F.[1]		Total	
		Naked	Mylar Cap	Naked	Mylar Cap	Naked	Mylar Cap
		Percent	Percent	Percent	Percent	Percent	Percent
50° F. 1 week	Wood-veneer	2.0	1.4	5.3	3.0	72	54
	Molded-pulp	5.0	1.0	7.4	2.0	38	53
	Plastic-mesh	2.7	1.7	5.9	3.0	52	40
	Waxed-chipboard	1.2	.2	3.4	.7	43	81
32° F. 2 weeks	Wood-veneer	4.5	1.7	6.6	2.5	42	43
	Molded-pulp	6.1	1.2	8.1	2.4	30	41
	Plastic-mesh	9.3	2.5	11.2	3.8	42	40
	Waxed-chipboard	3.7	.2	5.1	.7	29	50

[1] Accumulative weight loss. Includes loss during storage.
[2] Decay was determined at final examination following 2 days at 70° after storage.

Blueberries in wood-veneer pint-sized containers without film caps lost more weight during combined storage and holding than blueberries in containers capped with any of the films (table 6). Of the fruit in film-capped containers, that capped with 300 PHD cellophane,[4] 300 PI cellophane[5] or 0.5-mil Zytel (nylon) 42[6] lost the most weight. Berries capped with 300 DSB cellophane[7] lost the least weight. Those capped with 100-P912 cellulose acetate,[8] 300 MS86 cellophane,[9] 0.8-mil polyethylene or 1-mil Mylar (polyester) 44[10] lost intermediate amounts of weight. With some exceptions, weight loss was greater after 1 week at 50° F. plus 2 days at 70° than after 2 weeks at 32° plus 2 days at 70°.

Total decay, which was excessive in these tests, was greater during 50° F. storage (45-75% in table 6) than at 32° (36 to 56% in table 6). No consistent effect of the various film caps on decay was noted.

Moisture condensation was heaviest on films which allowed the least weight loss (fig. 6). It was slight or absent on films which allowed the most weight loss. Moisture condensed on all fruit moved from 32° or 50° to 70° F.; however, it soon evaporated during holding at 70° and 50 percent relative humidity. Condensation was heaviest and most persistent on 300 MS86 cellophane, 0.8-mil polyethylene, 1-mil polyester, and 300 DSB cellophane. It appeared for only short unobjectionable periods or not at all on 300 PHD cellophane, 300 PI cellophane, .5-mil nylon 42, or 100-P912 cellulose acetate.

4 Non-moisture proof, partially resistant to blocking in humid atmosphere.
5 Non-moisture proof.
6 Nylon film.
7 Partially moisture proof, anchor coated, heat sealable.
8 Non-moisture proof.
9 Moisture-proof, heat sealable.
10 Moisture-proof, heat sealable polyester film with polymer coating.

TABLE 6.--Weight loss, moisture condensation on films, and decay in packaged Croatan variety blueberries in wood-veneer pint containers capped with various films and stored 1 week at 50° F. and 85 percent relative humidity or 2 weeks at 32° and 85 percent relative humidity and held after storage for 2 additional days at 70° and 50 percent relative humidity

Type of film cap	Weight loss after indicated period -			Moisture condensation on films[1]			Total decay
	1 week at 50° F.	+2 days at 70° F.	Total	Stored at 50° F.	When moved to 70° F.	After 2 days at 70° F.	1 week at 50° F. + 2 days at 70° F.
	Percent	Percent	Percent				Percent
None (Control)	[2] 2.0	3.3	5.3	---	---	---	72
Cellophane 300PHD	2.1	2.4	4.5	None	None	None	55
" 300 PI	2.0	2.4	4.4	"	"	"	58
Nylon 42 (0.5 mil)	1.9	2.6	4.5	"	Moderate	"	56
Cellulose Acetate 100-P912	1.6	2.2	3.8	"	"	"	62
Cellophane 300MS86	1.2	1.8	3.0	Moderate	Heavy	Moderate	45
Polyethylene (0.8 mil)	1.2	1.8	3.0	Fairly heavy	"	Fairly heavy	54
Polyester 44 (1 mil)	1.4	1.6	3.0	Heavy	"	Moderate	54
Cellophane 300DSB	1.2	1.6	2.8	Moderate	"	"	75
	2 weeks at 32° F.	+2 days at 70° F.	Total	Stored at 32° F.	When moved to 70° F.	After 2 days at 70° F.	2 weeks at 32° F. + 2 days at 70° F.
	Percent	Percent	Percent				Percent
None (Control)	4.5	2.1	6.6	---	---	---	42
Cellophane 300PHD	2.4	1.2	3.6	None	None	None	56
" 300PI	1.7	1.7	3.4	Light	"	"	37
Nylon 42 (0.5 mil)	1.7	1.4	3.1	None	Heavy	"	46
Cellulose Acetate 100-P912	1.9	1.2	3.1	"	Moderate	"	41
Cellophane 300MS86	1.3	1.5	2.8	Moderate	Heavy	Moderate	44
Polyethylene (0.8 mil)	1.4	1.3	2.7	Heavy	"	Fairly heavy	36
Polyester 44 (1 mil)	1.7	.8	2.5	Fairly heavy	"	Moderate	43
Cellophane 300DSB	.9	1.0	1.9	Moderate	"	"	49

[1] Moisture condensed on all fruit in capped or noncapped packages moved from 32° or 50° to 70° F.
[2] Each percent figure based on 3 pint packages of blueberries.

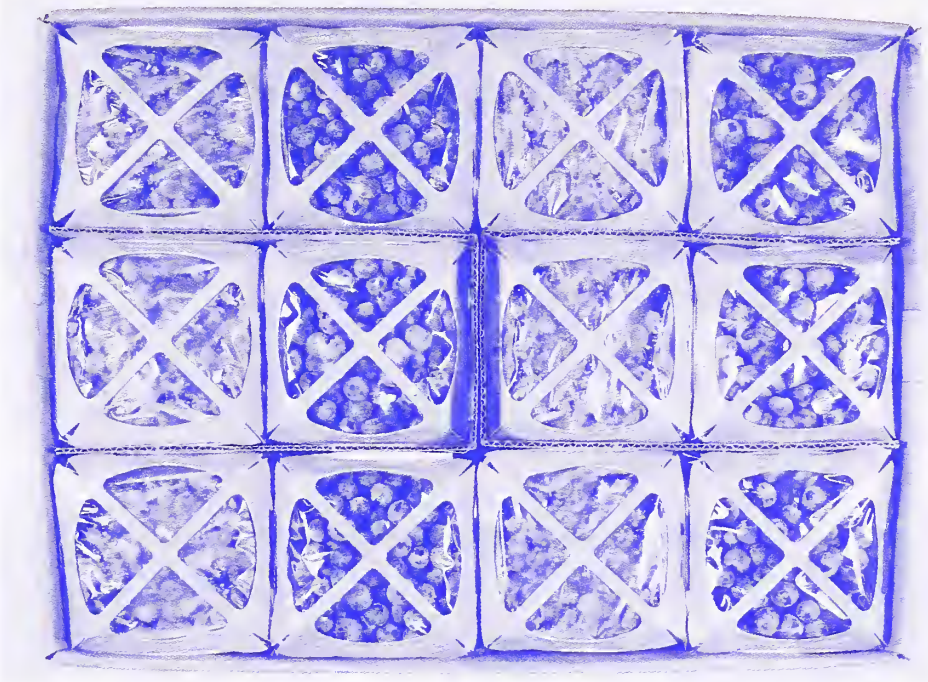

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FIGURE 6--Heavy moisture condensation on cellophane (1st and 3rd rows from left), interfered with visibility. Cellulose acetate (2nd and 4th row from left) allowed unobstructed visibility.

Since decay was not affected by film type, only cost, ease of handling, appearance, and weight loss need be considered in selecting a capping film. For short holding periods, 300 PHD and 300 PI cellophane, nylon, and cellulose acetate reduced weight loss moderately well and gave the package the best appearance. Where weight loss is a severe problem, 300 DSB cellophane or similar moisture retentive film should be used.

CONCLUSIONS

The high perishability of fresh blueberries indicates that extreme care is needed in handling this delicate fruit. For best results, blueberries should be kept at 32° F. and high relative humidity throughout storage and marketing. At higher temperatures, increased losses from decay can be expected.

Blueberries packaged ready for retail sale held up well (5 percent waste increase) at 32° F. for 2 weeks, at 40° for 1 week, and at 70° for 2 days. They held up fairly well (up to 10 percent waste increase) for 3 weeks at 32° or for 1 week at 32° plus 2 days at 70°, at 40° for 2 weeks, and at 50° for 1 week. At 85 percent relative humidity, weight loss from packaged blueberries averaged 1 percent per week at 32°, 1.5 percent per week at 40°, and 2 percent per week at 50°. At 70° F. with 50 percent relative humidity for 2 days, before or after storage, weight loss averaged 3.5 to 4 percent.

In limited tests, sealed 1.5-mil polyethylene lug liners increased the storage life of fresh blueberries at 32° F. by reducing weight loss and maintaining turgidity, appearance, and flavor. However, prolonged storage beyond 6 weeks resulted in off-odors and flavors in the polyethylene enclosed fruit. Weight losses were held to less than 2 percent for 5-7 weeks at 32° F. by using sealed or perforated film liners. Polyethylene stack covers were much less effective than lug liners in preventing weight loss and shriveling.

By selecting the proper container type and capping film, weight loss can be held to 2 or 3 percent or less during a normal storage or marketing period.

High amounts of decay were found in fruit in these limited tests. By using a 32° F. storage temperature, suitable containers and capping film, and care in packaging fairly decay-free fruit, it should be possible to market blueberries over a 2-week period following harvest. With some loss in quality, this can be extended to 4 weeks at 32°.

Wood-veneer or molded-pulp consumer containers with film capping seem generally suitable for packaging blueberries. Where weight loss is expected to be severe and decay is not a problem, waxed chipboard containers are suitable.

PHD-300 cellophane, PI-300 cellophane, 0.5mil nylon, and 100-P912 cellulose acetate are suitable as capping films. They reduced weight loss of the berries moderately, provided good transparency, and allowed little or no condensation. Where weight loss is a severe problem, 300 DSB cellophane or similar moisture-retentive films are satisfactory but moisture condensation may be more extensive.

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